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ABSTRACT

This mini-course and article are presentations from a workshop on computer-aided drafting. The purpose of the mini-course is to assist drafting instructors in updating their occupational knowledge to include computer-aided drafting (CAD). Topics covered in the course include general computer information, the computer in drafting, CAD terminology, CAD hardware, CAD software, CAD benefits, CAD drawbacks and limitations, and approaches for implementing CAD instruction in the classroom. The article reports on a survey of drafting instructors in Florida to determine their specific questions about computer drafting. Questions identified by the instructors as being of concern to them and the answers that were provided for them by sources in business, industry, and education are presented. These 18 questions include: What is computer drafting?, What types of drafting can be done with a computer?, Who develops the programs?, What specific computer-related skills will drafters need?, What topics should be included in a computer drafting course?, How can the drafting instructor best update skills to prepare to teach CAD?, and How can funding be acquired to cover the cost of purchasing a computer drafting system? Four sample drawings are provided. (YLB)

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Workshop Booklet

COMPUTER AIDED DRAFTING WORKSHOP

Prepared by:
Dr. David L. Goetsch

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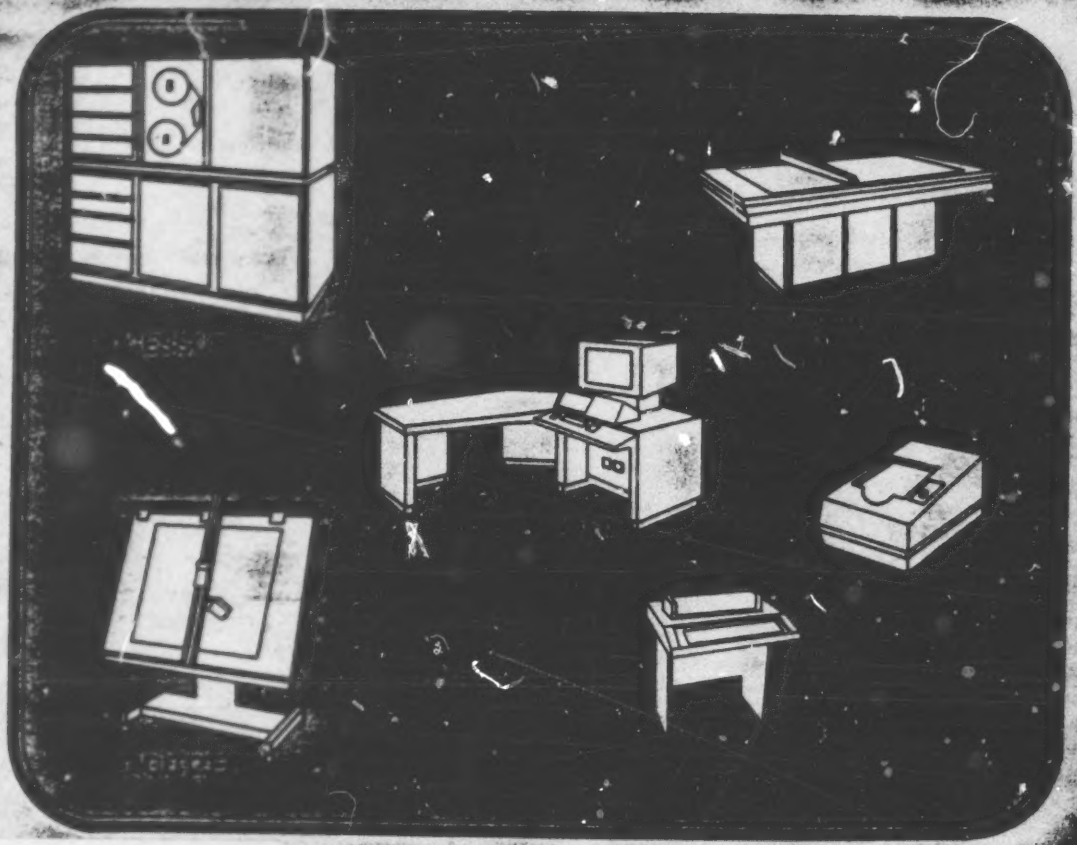

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WORKSHOP OUTLINE

First Day (March 5, 1981 - Thursday)

8:00 - 8:30	Welcome and Registration
8:30 - 9:30	"Computer Aided Drafting: A Mini-Course" - Dr. Goetsch "Answers To Your Questions On Computer Drafting" Presented by Dr. David L. Goetsch - OWJC
9:30 - 11:30	Computer Drafting Media - GAF Corporation
11:30- 12:30	OWJC Mall
12:30- 4:30	AD 380 Computer Drafting System - Auto Trol Corp.

Second Day (March 6, 1981 - Friday)

8:00 - 11:30	Tektronics 4050 Series Computer Drafting System presentation and "hands-on" activities.
11:30- 12:30	Lunch - OWJC Mall
12:30- 4:00	More "hands-on" activities on Tektronics System
4:00- 4:30	Closed remarks

Workshop Presenters

Dr. David L. Goetsch - Chairman, Industrial Education and Drafting Instuctor - OWJC

Mr. Frank DeCristina - Auto Trol Corporation

Mr. Chuck LaMotte - GAF Corporation

Mr. Don Neal - Tektronics Corporation

COMPUTER AIDED DRAFTING: A MINI COURSE FOR DRAFTING INSTRUCTORS

by

Dr. David L. Goetsch

No technological advance in the past three decades has impacted so profoundly on the occupation of drafting as the advent of computer aided drafting (CAD). Although CAD has been in use for over fifteen years, it was not until recently that the cost and performance of CAD systems were improved enough to bring about widescale adoption. Computer manufacturers have so improved both the cost and performance of their products, that today it is possible to purchase for $100 a computer that is equal to one which would have cost $1.000,000 only twenty years ago.

The coming of age of CAD represents a serious challenge in the area of occupational skills updating for drafting instructors. Before instructors can teach CAD, they must first learn it themselves. The purpose of this mini course is to assist drafting instructors in updating their occupational knowledge to include computer aided drafting. The course will cover: general computer information, the computer in drafting, CAD terminology, CAD hardware, CAD software, CAD benefits, CAD drawbacks and limitations, and recommend approaches for implementing CAD instruction in the classroom.

GENERAL COMPUTER INFORMATION

A computer is an electronic machine that, along with accompanying peripheral devices, is able to perform certain

types of work at amazingly fast speeds. The computer is capable of performing tasks in as little as one second that would take a human being a lifetime. This speed capability is the most important reason for the increasingly widespread adoption of computers in business and industry worldwide.

There are two general types of computers: digital and analog. Digital computers are the most common. They deal with logic and numbers. Most digital computers consist of three basic components: 1) the central processing unit (CPU), 2) input/output section, 3) internal memory. The CPU is broken into two sub-components: the arithmetic or logic unit and the control unit. These two sub-components have different functions and must be examined separately when discussing the CPU.

The arithmetic/logic unit does the computations required in completing a task. It receives data from the memory, stores it in its own storage positions temporarily, uses it to perform the mathematical functions specified by the control unit, and then transfers the answer to an output device so that it can be used. The control unit selects a set of instructions that have been placed in memory via a program and uses them to guide or control the computer. In other words, the control unit, as the name implies, tells the computer what to do.

Input devices allow human beings to interface with the computer either directly (on-line) or indirectly (offline) so as

to cause it to perform desired tasks or receive and store information. Input may be in the form of punched cards, magnetic tape, magnetic disks, or magnetic drums. Data may also be entered directly into the computer via a cathode ray tube (CRT) terminal. This device looks like a cross between a television and a typewriter. Input is entered by typing it on the CRT keyboard.

Output devices allow human beings to receive stored or computed data from the computer. Most input devices are also output devices. For example: if a person enters data into the computer through a CRT terminal, the terminal has served as an input device. If data is called up from storage and displayed on the CRT screen, the terminal has served as an output device.

The internal memory of the computer stores data and instructions that tell the computer what to do. Computers are often rated in terms of their storage capabilities. Other than speed, a computer's storage capability is its most important characteristic. If all other things are equal, the more storage capability a computer has, the better it is. A computer's storage capacity can be increased through the addition of a variety of external memory devices.

The computer requires two types of information in order to perform any task: 1) it must be provided the data that is to be acted on, and 2) it must be given instructions telling it what to do with the data. People communicate with computers

through the use of programs. Programs are logical, step-by-step instructions telling the computer what to do with data received. In order to guide the computer in the assigned task, programs must be written in a language that the computer understands.

Just as people from different countries speak different languages, computers manufactured by various companies for different applications also speak different languages. The most common computer languages are cobol, fortran, and basic. Cobol is the language of business computers. Fortran is a more technical language used primarily in scientific and engineering applications. Basic is a more general, all purpose language.

THE COMPUTER IN DRAFTING

The dawning of the 1980's saw widespread use of the computer as a drafting tool in American business and industry. One CAD manufacturer, Auto Trol Corporation in Denver, reported over 500 hundred companies using its computer drafting system. Other manufacturers such as Tektronics, Hewlett-Packard, IBM, and Nicolet CAD Corporation are also enjoying increasing acceptance and use of their CAD systems. The following companies are examples of the hundreds that have adapted CAD in every region of the country: Offshore Power Systems (a subsidiary of Westinghouse)--Jacksonville, Florida; Pennsylvania Power and Light--Allentown, Pennsylvania; Environmental Elements--Baltimore, Maryland; National Coal Resources Data Systems--Reston, Virginia; Morgan Construction Company--Worchester, Massachusetts; Ralph M.

Parsons Architects and Engineers--Pasadena, California; Firestone Tire and Rubber--Akron, Ohio; R. R. Donnally Company--Chicago, Illinois. Hundreds of other companies in every state have also adopted CAD.

Virtually every type of drafting is being done with the assistance of a CAD system. The leading manufacturers of CAD systems report that software packages are available and being used in electrical, electronic, mechanical, structural, architectural, piping, civil, and geological drafting, as well as three dimensional presentation drawings. This is important because the key to the versatility of a CAD system is its software.

COMPUTER AIDED DRAFTING TERMINOLOGY

The language of drafting has been added to since the advent of CAD. Those terms that are most important to understand in dealing with CAD follow:

Hardware - The acutal computer itself and peripheral devices or machines. The CRT, digitizer, graphics processor, plotter, hard copy unit, and printer are all CAD hardware.

Software - Includes all non-mechanical CAD components such as programs, printouts, and hard copies of drawings.

CRT - Cathode ray tube. Visual display device on which drawings may be called up from memory and displayed on the screen. Resembles a cross between a television and a typewriter. Drafters interact with the CRT through its keyboard or with a light pen.

Program - A plan or set of directions designed to cause the computer to solve a specific problem or perform a specific task.

Plotter - A hardware device resembling a drafting table that actually "plots" the drawing based on commands from the computer.

Digitizer - A hardware device that allows drafters to electronically trace sketches or drawings and commit them to the computer's memory.

Graphics Processor - This is the central processing unit for a CAD system.

Hard Copy Unit - A special device designed to make copies of drawings and printed matter.

Printer - A hardware device that provides printouts for bills of material, parts lists, or any other printed data that must accompany drawings.

COMPUTER AIDED DRAFTING HARDWARE

A complete CAD system includes the following items of hardware: a graphics processor, digitizer, CRT terminal, plotter, hard copy unit, and a printer. The most important of these items to the drafter are the digitizer, plotter, and CRT terminal. These are the pieces of equipment that the drafter interfaces with most in developing drawings.

Depending on the system, the digitizer may be as simple as a small graphics tablet or as complex as a complete drafting table with a drafting machine equipped for electronically tracing sketches or existing drawings. The CRT terminal resembles a cross between a television and a typewriter. It can serve as both an input and an output device. By punching the keyboard of the CRT the drafter is able to input information to cause the plotter to create a drawing. In this instance the CRT is operating in the input mode. By punching the keys again the drafter can call up a drawing out of memory and have it displayed on the screen. In this instance, the CRT is operating in the

output mode.

The plotter in a CAD system may be either of the flatbed or drum type. The flatbed type is the most popular because it resembles a regular drafting table. In fact, it is a drafting table. The primary difference between the flatbed plotter and a conventional drafting table is that the drafting machine on the plotter is manipulated by commands from the computer rather than manually by a human being. However, it should be remembered that although he or she may be once removed from the plotter, it is still the drafter that is giving the instructions that ultimately cause the drawing to be created.

COMPUTER AIDED DRAFTING SOFTWARE

Software, as was stated earlier, is the key to the versatility of a CAD system. The development of software packages that will allow computers to meet the specific drafting needs of individual companies is the major challenge confronting computer manufacturers.

Drafters are not computer programmers and do not need to be in order to operate CAD systems. On the other hand, computer programmers do not normally have a drafting background either. This paradox represents the primary inhibitor of the development of effective CAD software. However, through interfacing between drafters and software developers, significant advances have been made in this critical area.

Many manufacturers of CAD systems form software libraries and software associations. These things allow users of a

particular CAD system to obtain a wide range of software on a loan basis or at considerably less cost than if the programs were bought at normal market prices. Tried, tested, and improved software packages are now available for virtually every type of drafting.

BENEFITS OF COMPUTER AIDED DRAFTING

Users of CAD from all across the country report a number of expected and unexpected benefits. No time saving devices or method including templates and drafting machines can match the computer for speed. Because of this, repetitive drafting tasks are not a problem with CAD. The drafter simply instructs the computer to perform a given task the required number of times and goes on to other more important work. Repetitive work is where the computer really shines. It can perform repetitive tasks as much as ten times faster than a human being and do it more accurately and more neatly.

Most CAD systems make use of ink and paper as the drawing media. No combination of media can provide better reproductive capabilities. Hard copies and microfilm copies made of an inked original are the highest quality possible. Because of increasing use of microfilm copying for storing drawings, inked originals are becoming more and more important.

CAD systems have an unlimited number of lettering styles so that the drafter may choose any appropriate style for a set of drawings and all lettering on the drawings will be exactly the same. This is very important in certain drafting situations.

One is military or Department of Defense contracts. Military and DOD specifications require that a certain type of block lettering be used on all drawings submitted. In response, most companies require their drafters to use lettering templates on military and DOD drawings. This satisfies the uniformity specifications, but is inordinately time consuming. The computer is able to meet the uniformity requirement without time loss.

Drafting involves drawing a great number of various types of symbols. Because CAD systems have symbol libraries, drawing such things as electronic symbols for schematics, door and window symbols on architectural plans, or piping symbols on industrial layouts is as simple as pressing a button. Symbols can be created by the computer more than ten times faster than a drafter can create them with a template.

Drafting related computations are another of the CAD system's strong points. Such things as metric conversions, fraction to decimal conversions, and mathematical computations can be done automatically by the computer. Bills of material for structural drawings can be automatically compiled as the drawings are being done with CAD systems. This represents a considerable saving of time in structural steel and prestressed concrete drafting where the bill of material is an integral part of the working drawings.

The final benefit of CAD systems, but one of the most important, is a substantial storage capability. Drawings storage is a problem in any drafting department. Typically drawings are stored flat in special drawers. The drawers take up a lot of

space and hold a limited number of drawings. Many companies have begun to offset storage problems by microfilming original drawings. This is an improvement over the filing drawers, but it has its draw backs. Unless originals were created with microfilming in mind, they do not usually photograph well. This means that the permanent microfilm copy will be of poor quality. Companies using microfilm must also purchase expensive microfilm reading and copying equipment.

CAD systems have a storage capability that outreaches even the best microfilming systems. One roll of computer tape for a CAD system can store as many as 200 individual drawings. Drawings in storage may be called up and displayed on the CRT terminal by simply pressing a button and copied by pressing another button.

It is worth noting that many CAD users report that experienced drafters are able to learn to use a CAD system in as little as two weeks. This time frame presumes no previous experience in operating a computer. Other users reported a longer on the job training period before drafters are able to use a CAD system effectively. However, none of the users polled reported a training period of more than three months. The differences in times required to convert experienced drafters from manual to computer drafting are due to the different levels and types of drawings being produced by the different companies.

LIMITATIONS OF COMPUTER AIDED DRAFTING

The primary drawback of CAD systems in terms of educational institutions is cost. The cost of a CAD system, depending on the needs of the buyer, expectations of the system, manufacturer, and types of peripheral equipment desired can vary from as high as a quarter of a million dollars to as low as twenty thousand dollars. To an educational institution even systems at the low end of the cost spectrum are expensive.

There are several things that can be done to offset cost factors. One is to buy only the absolutely necessary items of hardware needed to prepare persons to operate CAD systems. By tying into a school's CPU and making use of CRT's that are already part of the school's facility, drafting instructors can get by with purchasing only a digitizer and plotter. Another possibility is to lease a CAD system and recoup the cost by contracting it out to local business and industry during its "down" hours.

Another drawback of CAD systems is that drafters on the job and drafting students in the classroom must be made aware of the purpose, expectations, and capabilities of the system as these things relate to them. Many people will look on the CAD system as a machine that is going to "put them out of work." One company reports that its drafting department personnel nicknamed their new CAD system the "eliminator."

Students and practicing drafters must be helped to realize that the CAD system will not put them out of work, but rather

it will help them to improve their work and do it faster. This in-born fear of technological advances is a very real consideration in implementing CAD. The success of CAD depends on the willingness of drafters to accept it and use it to improve practices in the drafting department.

It is helpful to present CAD as just another advance in time saving devices for drafting. First there was the T square, then the drafting machine, and now CAD. All of these things are simply tools to be used to improve drafting practices and the time involved in performing them.

RECOMMENDED APPROACHES FOR IMPLEMENTING COMPUTER AIDED DRAFTING INSTRUCTION

In spite of the cost factors involved in purchasing a CAD system, every educational institution that offers drafting can afford to teach CAD as part of their curriculum. There are three approaches to the implementation of CAD instruction, which involve three different levels of knowledge and skills development. The first approach will be called the primary approach, the next the secondary approach, and the last the tertiary approach.

The primary approach is the ideal approach. It involves purchasing a fully equipped CAD system with supportive software and writing a course that covers both theory and skills development. This approach results in students being able to actually create drawings, perform computations, compile parts lists, and develop bills of material via the CAD system. These students

could go directly from school into a job and perform drafting tasks on the computer from the moment they were employed.

The secondary approach is a watered down version of the primary approach. The main difference is that in the secondary approach only the bare necessities in hardware and software are purchased. These components are set up to interface with other computer devices already on hand to complete the system. This approach results in students knowing how to operate those devices that are purchased and with which they constantly interface. On the job, they would be required to familiarize themselves with any other CAD components that they were not used to working with.

The tertiary approach is one that any educational institution can afford to implement. In schools in which the business department offers computer courses, drafting students can be required to take a course in basic language programming, computer operation, or any other course that will allow them to become familiar with actually "pressing the buttons" on a computer terminal. The familiarity with computers gained in such courses as these will help alleviate the fears many drafting students have of dealing with the computer. Eliminating inherent mistrust of the unknown concerning computers will shorten the amount of on the job training required to convert students to productive computer drafters.

Another approach that falls under the tertiary concept is for those schools who do not offer computer courses. In this

case, the drafting instructor can write a course that facilitates computer familiarity using other tactics. This course should cover such topics as: general computer information, CAD terminology, CAD languages, different CAD systems, CAD hardware, CAD software, benefits and drawbacks of CAD, and the myths and realities of CAD. Classroom instruction can be supplemented with guest talks, films, and slide presentations provided by CAD manufacturers as well as field trips to companies using CAD systems.

The purpose of the tertiary approach is simply background and familiarity. The students are not able, through the approach, to develop CAD skills. However, a well trained drafting student who is familiar with CAD and is not afraid of it will quickly learn on the job.

Computer aided drafting is no longer something that drafting instructors can look forward to in the future. It is here now and its use is becoming more widespread daily. If drafting instructors are to continue preparing students for jobs in modern business and industry, they must begin to provide instruction in CAD. Most schools will not be able to immediately implement the primary approach to CAD instruction. Most will not even be able to implement the secondary approach. However, time is on the side of the drafting instructor in terms of CAD hardware and software. Each year these things become less and less expensive. In the mean time, every drafting instructor can at least take the tertiary approach to CAD instruction, and this should be done as soon as possible.

DRAFTING INSTRUCTORS: ANSWERS TO YOUR QUESTIONS ON COMPUTER DRAFTING

by

Dr. David L. Goetsch

The dawning of the 1980's saw widespread use of the computer as a drafting tool in business and industry worldwide. No technological advance in the past 30 years has impacted so profoundly on the occupation of drafting as the advent of computer drafting. For drafting instructors, increasingly widespread adoption of computer drafting systems represents a significant challenge in the area of occupational updating.

As part of a study of the implications of computer drafting for vocational drafting programs, the author undertook to determine what specific questions drafting instructors had about computer drafting. The idea was to ask drafting instructors what concerned them most about computer drafting and then obtain answers to their questions.

In order to determine what the questions were, numerous interviews were held with drafting instructors. Their questions were recorded and then converted into a survey instrument. This instrument contained a complete list of all questions that had been posed by drafting instructors during the preliminary interviews. The instrument was mailed to a sample of all drafting instructors in the state of Florida. All recipients were asked to rate each question as being one in which an answer was "badly needed," "needed," "no opinion,"

or "not needed." In addition to rating the questions included on the survey instrument, subjects were asked to list any additional questions about computer drafting that concerned them.

Obtaining answers to all questions rated as "needed" or "badly needed" and to any additional questions that subjects listed involved general data gathering methodologies. Over 100 hundred pieces of literature were reviewed, several computer drafting manufacturers were interviewed; visits were made to companies using computer drafting systems; information was collected from the leading manufacturers concerning cost data, hardware, software, and media; and teachers actually involved in computer drafting were interviewed for recommendations on implementing computer drafting instruction.

What follows are those questions identified by drafting instructors as being of concern to them and the answers that were obtained for each question.

1. What is computer drafting?

   Before defining computer drafting, it might be helpful to define drafting. Drafting is the process by which design ideas are committed to paper or any other form of media. The most common result of a drafting effort is a plan or set of plans that will guide workers in the building or manufacturing process. Drafters use many tools and time saving devices in drawing plans. The computer is another drafting tool or time saving device to help drafters perform their job more rapidly and more efficiently.

2. What companies across the country are using computer drafting systems?

   Hundreds of companies are now using computer drafting systems.

In fact, many have been using computer drafting for as much as 15 years. The following list of computer drafting users was supplied by the Auto Trol Corporation in Denver, Colorado. These companies are only a small sample of the many using computer drafting.

Alcan, Alcoa, Allied Chemical, Amoco Oil Company, Amoco Production Company, Anchor/Darling Valve Company, Applied Graphics, Automated Design Systems, Black and Veatch Consulting Engineers, C.F. Braun and Company, Brown and Campbell, Burns and Roe, Butler Manufacturing Company, CAE Electronics, Canadian Drafting Systems-Ltd., Clinton Corn Processing Company, Inc., Clyde E. Williams and Associates, Davy-Loewy-Ltd., Digital Drafting Corporation, R.R. Donnelly and Sons, Environmental Elements Corporation, Exxon, Firestone Tire and Rubber, Fruehauf Corporation, Frito-Lay, Inc., General Motors, General Railway Signal Corporation, Goodyear Tire and Rubber Company, GTE Sylvania, Imperial Oil, Ltd., International Minerals and Chemical, Lawrence Livermore Labs, Master Design Corporation, Morgan Construction, Natural Gas Pipeline, Nuclear Power Services, Inc., Offshore Power Systems, Ralph M. Parsons Company, Pennsylvania Power and Light Company, Phillips Petroleumm Pipeline Technologies, Inc., Pullman Kellogg, Sears, Roebuck and Company, Shell Canada Ltd., Shell Development Company, Shell Oil Company, Stromberg Carlson, and Albert Switzer and Associates.

3. What types of drafting can be done with a computer?

Computer drafting systems can do any type of drafting they are programmed to do. The key to the versatility of a computer drafting system is the software. The major manufacturers of computer drafting systems report that software packages are available for architectural, mechanical, civil, structural, electrical, electronics, geological, and piping drafting as well as three dimensional presentation drawing.

4. What specific drafting tasks can be accomplished with a computer?

Virtually any drafting task that can be performed manually can be performed with the computer and peripheral equipment. It should be remembered that the computer is simply a technologically advanced tool to help drafters perform their normal duties. The computer can lay out the floor plan, electrical plan, foundation plan, wall sections, plot plan, HVAC plan, and elevations for a set of residential

plans. It can layout schematics and PC boards in electronics drafting. It can create piping diagrams in orthographic or axonometric projection, develop framing plan, sections, and details in structural drafting, layout complete subdivision plats in civil drafting, compile parts lists, develop bills of material, and perform an unlimited number of mathematical computations. The computer can perform virtually any drafting task with the help of a well written program and a skilled drafter.

5. Is their a correlation between the number of drafters employed by a company and the cost effectiveness of purchasing a computer drafting system?

   Most manufacturers and companies polled felt that the correlation was between the amounts of drafting done, not the number of drafters employed. However, since it is normal to have a definite correlation between the number of drafters employed and the amount of drafting done, there seems to be at least an indirect relationship between computer cost effectiveness and the number of drafters. Although it cannot be said that computer drafting will be cost effective for any company that employs a given number of drafters, it should be noted that most companies using computer drafting do have a large drafting department. Most companies identified as users of computer drafting systems employed a drafting force of more than ten people.

6. What hardware is included in a computer drafting system?

   Manufacturers of computer drafting systems give different names to the various pieces of hardware that make up their product. The names will vary from manufacturer to manufacturer, but a complete computer drafting system with all peripheral devices will include: a processing unit, plotter, digitizer, CRT terminal, printer, and hard copy unit. The AD 380 computer drafting system manufactured by the Auto Trol Corporation is illustrated on this page.

7. Who develops the programs for computer drafting systems?

   Generally speaking, the hardware manufacturer has a software component for developing computer drafting programs. These programs are purchased by users. Several manufacturers maintain a "user's library" so that companies purchasing their equipment will have ready, inexpensive access to computer programs that might improve their operation. Some companies do have their own programmers that work with drafters in developing programs to meet their specific drafting needs.

11. How much do computer drafting systems cost?

Without speaking to the numerous variables and options affecting the cost of a computer drafting system, it is safe to say that one might spend as little as $20,000 or as much as $250,000 on a computer drafting system. The cost is tied to the type of drafting to be done, the level of that drafting, the amount of drafting to be done, the various peripheral devices desired, the availability of computer equipment already on hand that can be tied into, and so on.

Any institution expecting to buy a complete computer drafting system such as the one illustrated on the preceding page can expect to spend between $100,000 and $200,000. Institutions that are able to tie in to existing central processing units, printers, and hard copy units, thereby necessitating the purchase of only the digitizer, CRT terminal, and plotter, can decrease their costs considerably.

12. What topics should be included in a computer drafting course?

There are several approaches available to instructors wishing to implement computer drafting instruction. The first approach involves purchasing enough hardware to allow for theory and skills development. The theory portion should cover such topics as: general computer information; the computer in drafting; computer drafting terminology; computer drafting hardware, software, and media; computer languages (familiarity only); and employment as a computer drafter. The skills portion should involve actual development of manual skills in the operation of the computer drafting hardware.

Those institutions that are not able to purchase a computer drafting system outright or obtain one through interfacing with computer equipment already on hand can still offer computer drafting instruction.

By offering the theory portion of the instruction as presented above and supplementing it with some of the many computer drafting films, slide presentations, guest speakers, and field trips available from computer manufacturers, any drafting instructor can provide his or her students with enough background that they will be able to quickly acquire manual skills on the job.

13. How urgent is the need to implement computer drafting instruction?

The need is very urgent. Computer drafting is no longer

something with which drafting instructors will have to deal in the future. The need for computer drafting instruction is upon us now. Many graduates of the nation's vocational drafting programs will seek jobs with companies using computer drafting this year. Others will find themselves employed by companies that intend to convert to automated drafting in the near future. Every drafting program should be providing computer drafting instruction now, even if it is only to provide background and familiarity.

14. How can the drafting instructor best update his or her skills to prepare to teach computer aided drafting?

Theory oriented information is available in abundant supply. In Florida, the Florida Educator's Information Service (FEIS) will conduct a computer search of recent literature and provide any vocational instructor in the state an annotated bibliography of literature on computer drafting. Hands on skills can be developed by contacting computer manufacturers and arranging one on one workshops. As time goes by and computer drafting achieves even wider acceptance, workshops through the department of education and professional organizations will begin to spring up to help drafting instructors update their knowledge and skills in this vital area.

15. Will implementation of computer drafting decrease the number of jobs available in drafting?

The types of jobs that have the potential for being eliminated by computer drafting are not jobs that vocational drafting students are prepared to do in the first place. It is possible that elementary tracing positions may be eliminated by the computer because one of its strong points is that it decreases the amount of repetitious work. However, drafting level positions will not be eliminated by computer drafting. The drafters that were performing manual drafting tasks prior to implementation of computer drafting will perform the same tasks faster and easier with the computer.

This concern over less jobs and loss of jobs is one of the most critical issues impacting on computer drafting. People have an inherent fear of automation and in many cases their fears are justified. Ever since the fictitious character, John Henry, became famous for his struggle against a machine that was going to replace him on the railroad, skilled workers have had a tendency to wonder when they might be replaced by a machine.

One company that converted to automated drafting reported that its drafting personnel nicknamed the new computer

drafting system the "eliminator." However, as they became more and more proficient in its use, they realized that the computer had actually enhanced their job rather than eliminating it.

16. What companies manufacture and distribute computer drafting hardware and software?

There are numerous companies involved in the manufacture of computer drafting systems and supportive software. This alone is evidence of how computer drafting is growing. Some of the leaders in the field of computer drafting are:

Auto Trol Corporation--Denver, Colorado; Tektronics--Beaverton, Oregon; Nicolet CAD Systems--Berkeley, California; I Corporation--Berkely, California. Several other well known manufacturers of computers such as IBM and Hewlett-Packard have expanded into computer drafting too.

17. What guidelines should drafting instructors follow in purchasing computer drafting hardware?

A. Compile a list of users of computer drafting and determine what types of systems are being used most.

B. Contact the manufacturer of the most widely used system and ask a representative to visit your drafting program and make recommendations as to what hardware is needed, how existing computer equipment can be made use of to cut costs, and how a computer drafting system can be installed at the least expense.

C. Once step "B" above is completed and you know more about what your needs really are and what is required to meet them, invite several computer drafting manufacturers to come into your facility and repeat step "B".

D. Ask for itemized bids from those manufacturers that visit and evaluate your situation. Narrow the list of manufacturers down to two or three.

E. Take the itemized bids to several companies using computer drafting and ask them to help you make an evaluation. Based on this input, select a system.

F. Identify one or two companies using the system you have selected and ask them to provide a list of any problems they had during ordering, shipping, set up,

and in using the system. Let the manufacturer know that you wish these same problems to be avoided in your case.

18. How can funding be acquired to cover the cost of purchasing a computer drafting system?

This is the most difficult area for vocational instructors because computer systems are expensive and funding for education is limited. However, there are some options. The first funding source is the "Federal Funding Guide." Vocational instructors are allowed to submit proposals for projects through the "Federal Funding Guide" once each year. This is a good source for large sums of money, such as the amounts needed to purchase a computer drafting system. Before submitting a proposal, make sure that your institution accepts the computer drafting system as a high priority project. This will inhance your chances of being funded.

State and local grants tied to some specific area such as improvement of educational opportunities for minorities or the handicapped are another potential source. The state and federal government are constantly pushing for more and better ways to serve persons in these groups. Large companies using computer drafters are in the market for well trained, highly skilled minorities and handicapped. Computer drafting offers instructors an opportunity to expand their contributions into these critical areas, which, in turn, improves their chances of receiving funding.

Another possible outlet comes from manufacturers themselves. Several of the larger manufacturers of computer hardware and software make grants available to educational institutions to help them move into computer related instruction. One computer manufacturer has its own educational foundation that grants computer hardware to institutions in return for any software instructors might develop. The school benefits from receiving expensive hardware free of charge and the manufacturer benefits from software the instructors develop.

The questions presented in this article have been those that drafting instructors identified as weighing heavily on their minds in terms of computer aided drafting. Answers were provided by sources in business, industry, and education.

Knowing the answers to questions such as those dealt with in this article should do two things for drafting instructors: 1) it should set their mind at ease concerning this new and sometimes frightening technological development that is beginning to impact on their field, and 2) it should point out the need for participation in activities designed to update their occupational skills in this new area. This is the next, and most critical step for drafting instructors.

BILL OF MATERIAL TAKE-OFF

FITTINGS, VALVES, AND FLANGES

00005	150 ANSI	SCHED	40	8 INCH	90 DEG L RAD ELL	BUTTWELDED
00001	150 ANSI	SCHED	40	8 INCH	45 DEG ELBOW	BUTTWELDED
00001	150 ANSI	SCHED	10	8 INCH	90 DEG ELBOW	BUTTWELDED
00002	150 ANSI	SCHED	40	2 INCH	90 DEG ELBOW	THREADED
00002	150 ANSI	SCHED	40	2 INCH	TEE	THREADED
00001	150 ANSI	SCHED	40	8 INCH	TEE	BUTTWELDED
00004	150 ANSI	SCHED	40	10 INCH	WELD NECK FLANGE	RAISED FACE
00002	150 ANSI	SCHED	40	8 INCH	WELD NECK FLANGE	RAISED FACE
00001	150 ANSI	SCHED	40	8 INCH	GATE VALVE	RAISED FACE
00001	150 ANSI	SCHED	40	8 INCH	SADDLE	BUTTWELDED
00002	150 ANSI	SCHED	40	2 INCH	SADDLE	THREADED
00002	150 ANSI	SCHED	40	10 INCH	1/8" GASKET	RAISED FACE
00002	150 ANSI	SCHED	40	8 INCH	1/8" GASKET	RAISED FACE
00002	600 ANSI	SCHED	40	6 INCH	90 DEG L RAD ELL	BUTTWELDED
00001	600 ANSI	SCHED	40	6 INCH	90 DEG ELBOW	RAISED FACE
00001	600 ANSI	SCHED	40	6 INCH	45 DEG ELBOW	BUTTWELDED
00002	600 ANSI	SCHED	40	10" X 10" X 6	TEE REDUCING	BUTTWELDED
00007	600 ANSI	SCHED	40	6 INCH	WELD NECK FLANGE	RAISED FACE
00001	600 ANSI	SCHED	40	6 INCH	GLOBE VALVE	RAISED FACE
00006	600 ANSI	SCHED	40	6 INCH	1/8" GASKET	RAISED FACE

TOTAL PIPE LENGTHS

0000040.51	150 ANSI	SCHED	40	2	INCH
0000024.43	150 ANSI	SCHED	40	8	INCH
0000004.64	150 ANSI	SCHED	40	10	INCH
0000031.25	600 ANSI	SCHED	40	6	INCH

CUT PIPE LENGTHS

0000004.64	150 ANSI	SCHED	40	2	INCH
0000004.62	150 ANSI	SCHED	40	2	INCH
0000010.46	150 ANSI	SCHED	40	2	INCH
0000010.65	150 ANSI	SCHED	40	2	INCH
0000010.14	150 ANSI	SCHED	40	2	INCH
0000002.75	150 ANSI	SCHED	40	8	INCH
0000004.58	150 ANSI	SCHED	40	8	INCH
0000001.42	150 ANSI	SCHED	40	8	INCH
0000000.33	150 ANSI	SCHED	40	8	INCH
0000005.65	150 ANSI	SCHED	40	8	INCH
0000009.70	150 ANSI	SCHED	40	8	INCH
0000003.65	150 ANSI	SCHED	40	10	INCH
0000000.49	150 ANSI	SCHED	40	10	INCH
0000000.50	150 ANSI	SCHED	40	10	INCH
0000003.36	600 ANSI	SCHED	40	6	INCH
0000000.50	600 ANSI	SCHED	40	6	INCH
0000000.50	600 ANSI	SCHED	40	6	INCH
0000003.38	600 ANSI	SCHED	40	6	INCH
0000009.05	600 ANSI	SCHED	40	6	INCH
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0000000.50	600 ANSI	SCHED	40	6	INCH
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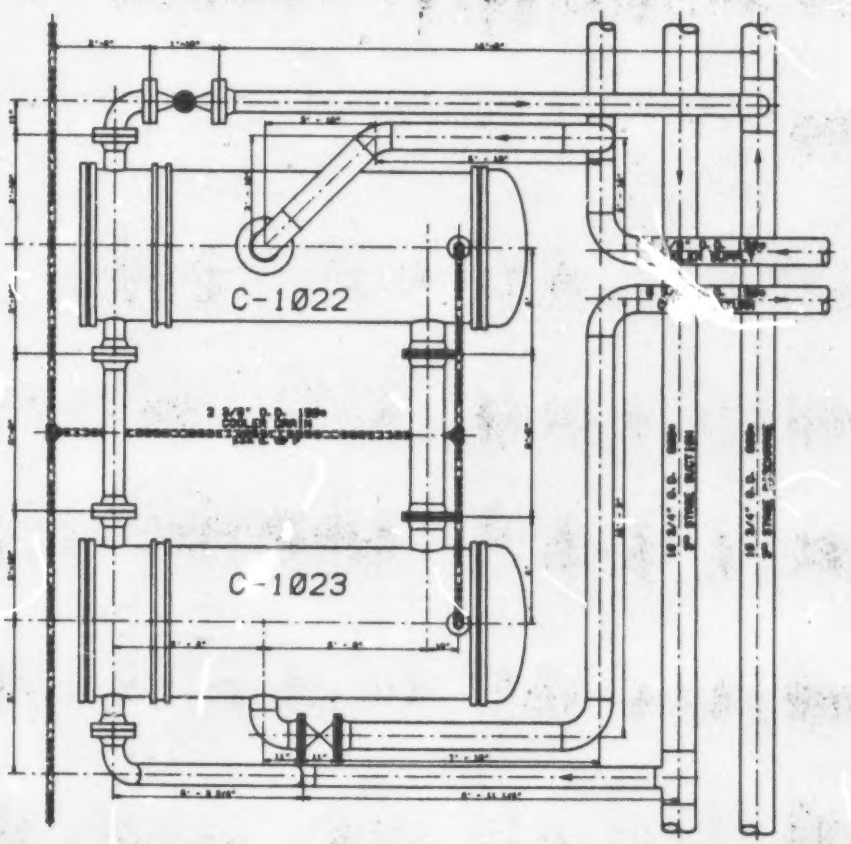

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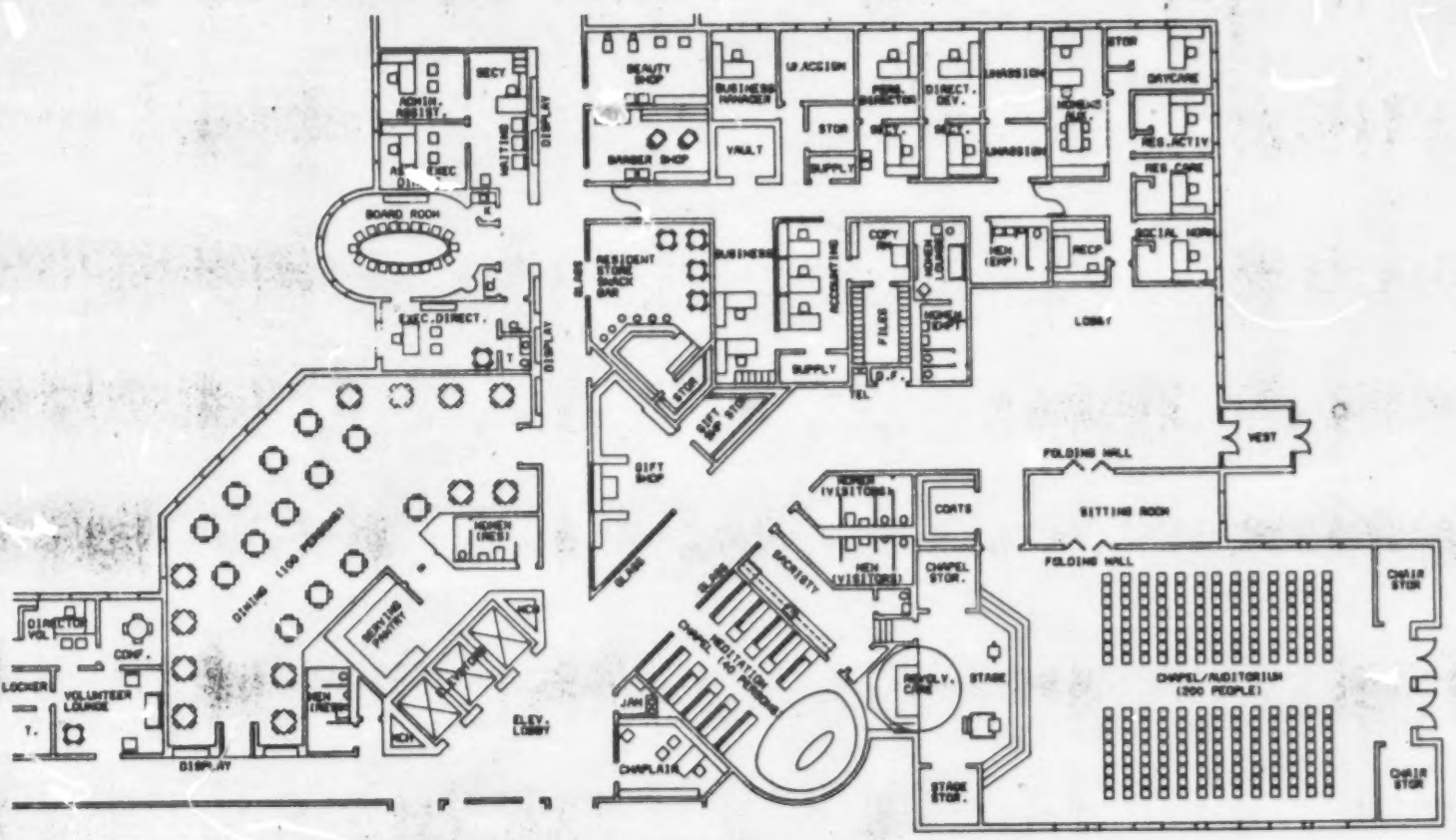

PARTIAL FLOOR PLAN

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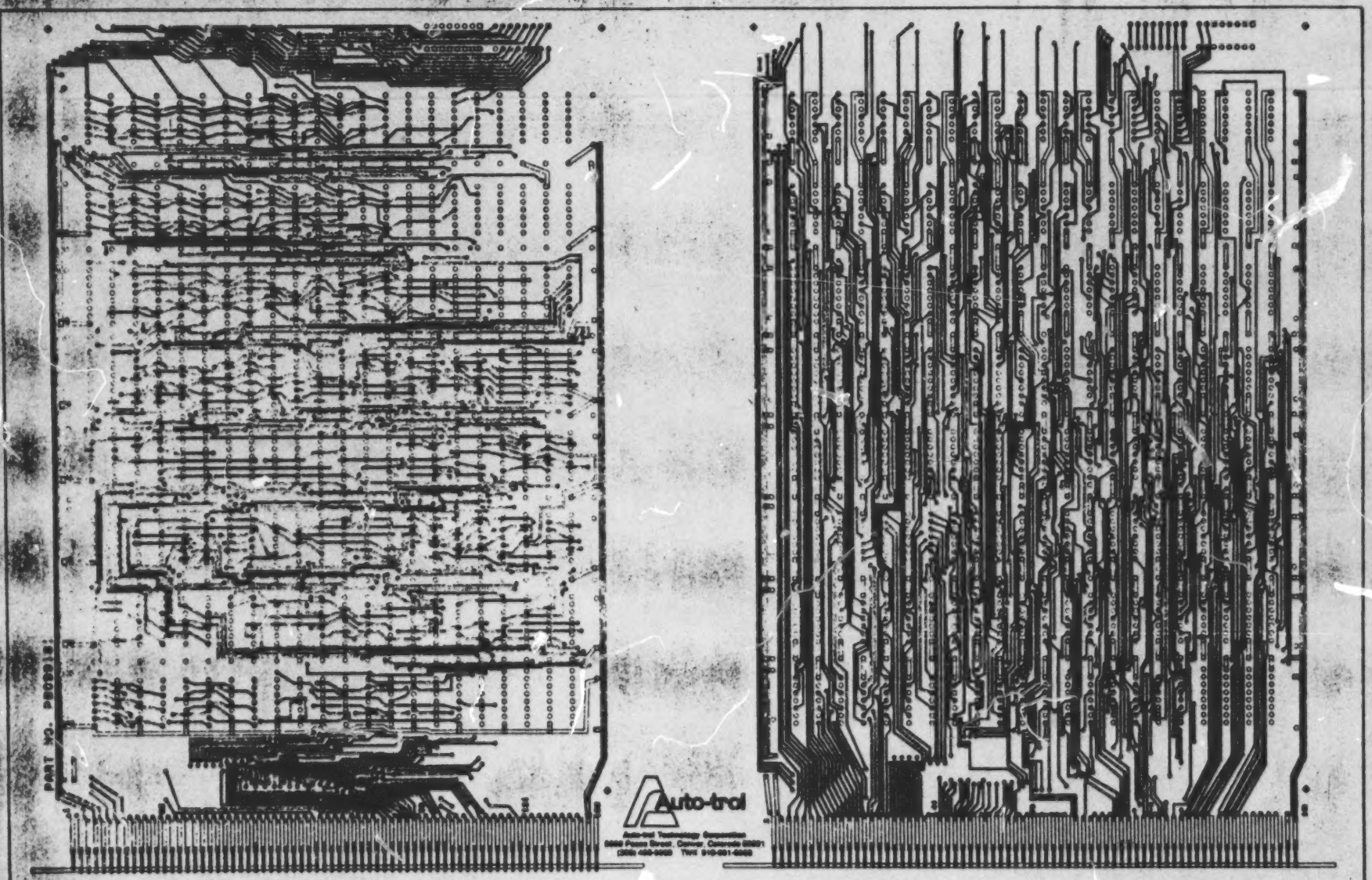
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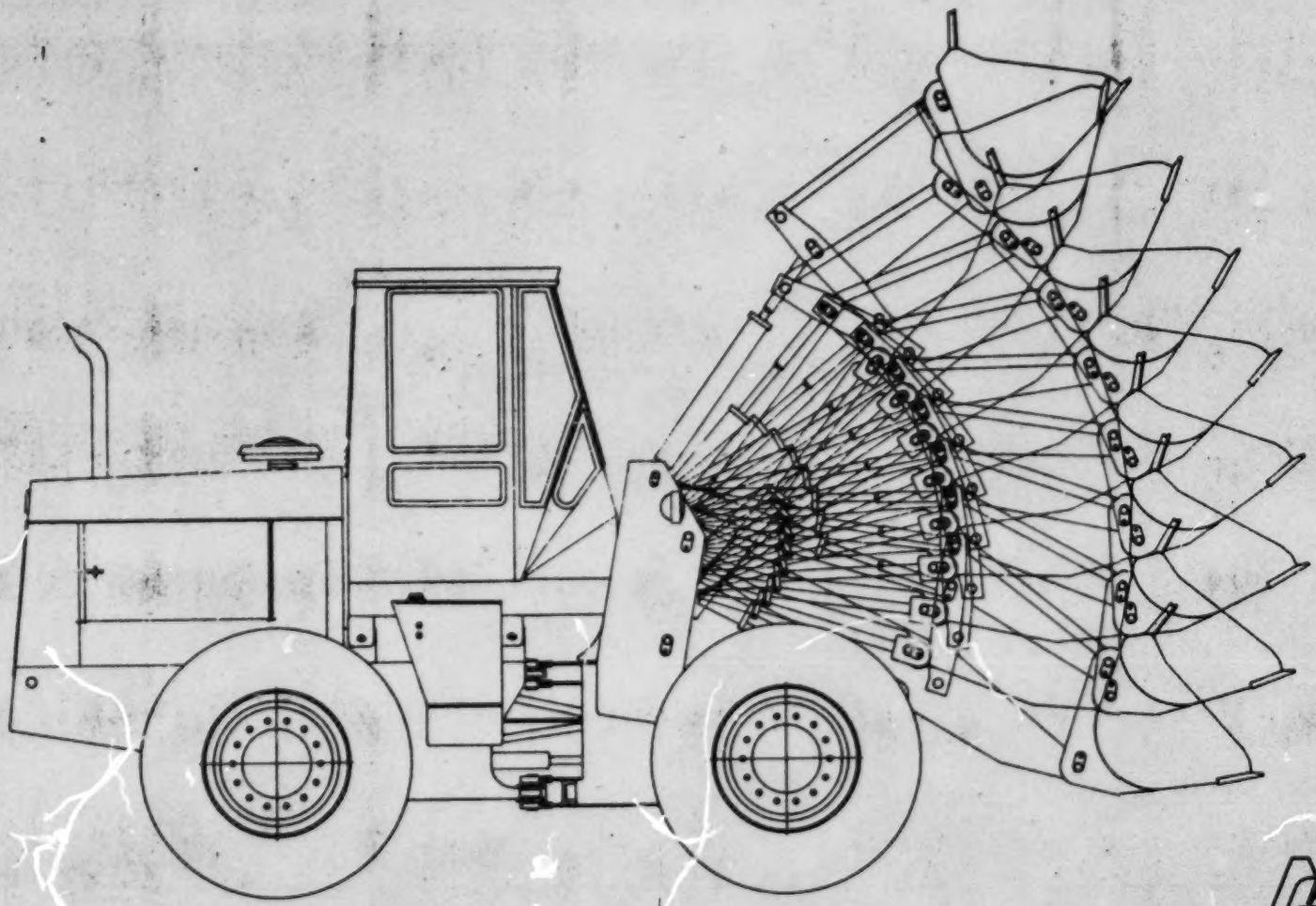
THIS PRINTED CIRCUIT BOARD WAS CREATED ON THE "AUTO-DRAFT" IN 10 HOURS. INPUT WAS A FREEHAND LAYOUT ON GRID PAPER. COLOR CODED FOR TRACE SIZES.



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